Surface energy coefficient of a low density nuclear system

J. B. Elliott, L. G. Moretto, L. Phair, and G. J. Wozniak

Since the earliest observations of nuclear multifragmentation (the break up of excited nuclei), the Fisher Droplet Model (FDM) [1] has been employed in attempts to understand this phenomenon. It still enjoys great popularity and has been employed in the analysis of the EOS Au multifragmentation data [2]-[4].

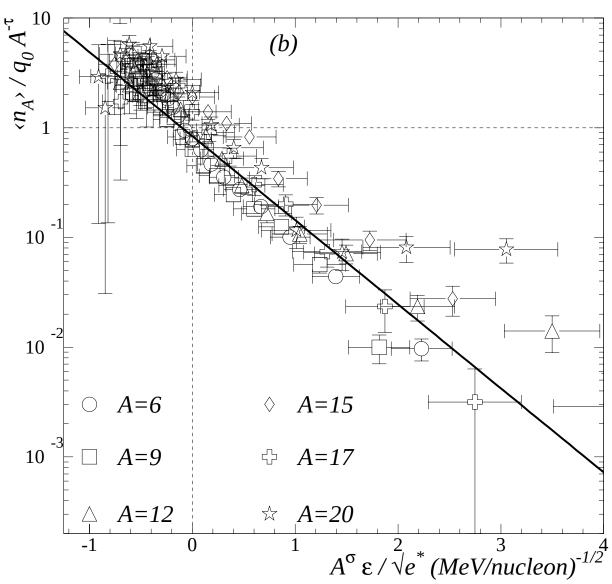

Figure 1: Scaled fragment distribution as a function of the scaled control parameter for fragments of mass A; solid line: a fit to the FDM.

The FDM is based on the equilibrium description of droplets. The mean number of droplets of size A is written as:

$$\langle n_A \rangle = \left\langle \frac{N_A}{A_0} \right\rangle = q_0 A^{-\tau} \exp\left[\frac{A\Delta\mu}{T} - \frac{c_0 \epsilon A^{\sigma}}{T}\right],$$

where: $\Delta\mu = \mu - \mu_l$; μ and μ_l are the actual and liquid chemical potentials respectively; A_0 is the size of the system; q_0 is a normalization constant depending only on the value of τ; τ depends on the dimensionality of the system; $c_0 \epsilon A^{\sigma}$ is the surface free energy of a droplet; c_0 is the surface energy coefficient; σ is the critical exponent related to the ratio of the dimensionality of the surface to that of the volume; and $\epsilon = (T_c - T)/T_c$ is the control parameter, a measure of the distance from the critical point, T_c.

Fig. 1 shows a plot of the EOS Au multifragmentation data [2]-[4]. The substitution of $\sqrt{e^*} = \sqrt{E^*/A_0}$ for T has been made resulting in a control parameter of $\epsilon = (\sqrt{e_c^*} - \sqrt{e^*})/\sqrt{e_c^*}$; for a degenerate Fermi gas reduces to $(T_c - T)/T_c$. The excitation energy normalized to the mass of the fragmenting remnant, e^* in MeV/nucleon, excludes collective effects [3]. The location of the critical point, e_c^*, and values of the critical exponents, σ and τ, were determined previously [2]-[4]. Fitting n_A^{scaled} as a function of ϵ^{scaled} for $\epsilon \geq 0$ and leaving c_0 and $\exp\left[A\Delta\mu/\sqrt{e^*}\right]$ as free parameters in the FDM gives $c_0 = 6.4 \pm 0.6$ MeV (via $E^* = aT^2$ with $a = A_0/13$) and $\exp\left[A\Delta\mu/\sqrt{e^*}\right] = 0.8 \pm 0.1$, *i.e.* the bulk term is consistent with $\Delta\mu \approx 0$. The temperature independent surface energy coefficient c_0 is of a different nature than the semiempirical mass formula parameter ($a_s \sim 17$ MeV for $T = 0$, $\rho = \rho_0$) or estimates for low density nuclear systems ($a_s \sim 6$ MeV for $T \sim 3$ MeV, $\rho \sim \rho_0/3$) [5].

References

[1] M. E. Fisher, Physics **3**, 255 (1967).

[2] M. L. Gilkes, *et al.*, Phys. Rev. Lett. **73**, 1590 (1994).

[3] J. A. Hauger *et al.*, Phys. Rev. C **57**, 764 (1998).

[4] J. B. Elliott *et al.*, Phys. Lett. B. **418**, 35 (1998).

[5] A. S. Hirsch *et al.*, Phys. Rev. C **29**, 508 (1984).